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Ground Water Research Plan

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Ground Water Research Plan

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16. ABSTRACT

This document sets out the objectives of the Environmental Protection Agency's ground-water research; specifies the Agency's legislative mandates in ground water; describes the research activities which support those mandates with explicit time frames; and identifies the clients of the research.

The plan is limited to only those EPA activities directly in support of solving ground-water problems. As a result. it does not include discussion of health effects research related to drinking water (including ground water), drinking water treatment technology development, research on technology for controlling releases into the subsurface environment, and, finally, assessment of the quantity and quality of the Nation's ground-water resources, which is the responsiblility of the U.S. Geological Survey.

Within this limited scope, the main EPA research activities are directed toward developing less costly and more accurate methods for detecting ground-water pollution; improving the scientific knowledge for predicting the movement, transformation, and fate of contaminants released into the ground-water environment; assessing the strategies and cost-effectiveness of the reclamation of polluted ground water; and enhancing the availability and accessibility of technical information related to ground-water pollution.

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INTRODUCTION

This Ground Water Research Plan was prepared by the U.S. Environmental Protection Agency (EPA) specifically in response to Section 2(a) of the Environmental Research, Development, and Demonstration Authorization Act of 1981 (Public Law 96-569). The plan describes research EPA is conducting and intends to conduct to better understand the subsurface environment. The results of the research described in the plan are needed by State and local agencies and industry, as well as specific EPA offices. These will fill important gaps in our understanding of ground-water pollution. Moreover, the information generated under this plan will help decision makers to more safely and effectively dispose of hazardous materials.

EPA believes that better understanding of ground-water pollution will lead to better protection of ground-water quality. By addressing areas where technical deficiencies exist, this research plan complements a broad base of research which has already been done by EPA and others.

The objectives of the research are to:

- Develop methods for the detection of ground-water pollution
- Understand the movement, transformation, and fate of contaminants released into the subsurface environment
- Determine how the behavior, movement, and characteristics of pollutants are altered during their passage through the subsurface environment
- Identify the extent and kind of ground-water pollution resulting from specific sources of contamination
- Assess the strategies and cost effectiveness of aquifer rehabilitation
- Enhance the availability and accessibility of technical information related to ground-water pollution

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This document does not provide extensive information on the state of ground-water technology or on the state of knowledge concerning ground-water research. To do this would require recounting a considerable amount of background information which is readily available elsewhere.

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THE PROBLEM

PROBLEM DEFINITION

Accessible, fresh ground water constitutes one of the Nation's most valuable natural resources, exceeding surface water in quantity and generally in quality. Ground water is a reliable resource compared to surface water, in that it is not subject to extreme temperature and quality fluctuations. Ground water supplies the domestic water needs of 80 percent of all public water supply systems and 96 percent of rural America. Overall, about one-half of all U.S. residents rely on ground water as their primary source of drinking water. Ground water has traditionally been and continues to be a major source for industrial process water. Moreover, it has come into rapidly increasing use for livestock production and agriculture. Through supplemental irrigation, it may be one of the most promising means for increasing agricultural production in the future.

Despite its essential role in the Nation's economy and welfare, this water resource has been inadequately protected, in large measure because, until recently, conventional wisdom taught that nature protected our underground water much more than it actually does. Unfortunately, most of our activities on the land directly affect the quality of ground water, especially the near-surface aquifers. Because so many people in the United States depend on ground water as their only supply of drinking water, it is essential for maintenance of public health and environmental quality that we direct attention to the protection of ground-water supplies.

However, with growing frequency, new instances of ground-water contamination are reported. Dramatic problems such as Love Canal and the

Valley of the Drums have attracted national attention, but numerous other examples of ground-water contamination have also been discovered.

NEED FOR INFORMATION

The U.S. Environmental Protection Agency (EPA) has received numerous requests from State and local governments for information and assistance when ground-water problems have been discovered. Definition of the major causes of contamination and development of programs to prevent future contamination are required. Detecting and cleaning up contamination are difficult and costly operations. By providing a better understanding of these problems, EPA can help decision-makers deal with ground-water pollution more effectively and efficiently.

As States assume greater responsibility and mount more aggressive efforts to conduct ground-water quality sampling and as more ground-water monitoring is conducted under hazardous waste programs, more local instances of ground-water contamination will be discovered. The need for ground-water technical information by regional, State, county, and municipal agencies and by industry to deal with these problems will be critical.

EPA and the States also have a need for cost-benefit studies, risk assessment, health protection, and monitoring studies related to their responsibilities in ground-water protection in order to implement regulatory reform and make decisions based on sound scientific principles. Statutes dealing with ground water include: the Clean Water Act; the Safe Drinking Water Act; the Resource Conservation and Recovery Act; the Toxic Substances Control Act; the Comprehensive Environmental Response, Compensation, and Liability Act; the Energy Security Act (monitoring guidelines); the Atomic Energy Act; and the Uranium Mill Tailings Radiation Control Act. Response to these laws requires better information regarding the nature and extent of ground-water pollution and cost-effective mitigative measures.

RESEARCH RESPONSE

EPA has developed a ground-water research program designed specifically to provide information needed by managers of ground-water protection programs at the Federal, State, and local levels. Table 1 lists some of these clients and their specific responsibilities.

EPA's ground-water research program will provide information which will contribute to our understanding of the subsurface movement of contaminants from spills, leakage from the underground storage of oil and other chemicals, *in situ* mining operations, and waste disposal. It will provide information needed by legislators and regulators addressing the effects of oil and hazardous materials on drinking water quality.

EPA needs technical information that will result from the research to aid in the implementation of sole source aquifer guidelines and underground injection control regulations and to provide information useful to the States in their assumption of primary responsibility for implementing: the underground injection program; solid and hazardous waste regulations; guidelines for land application of wastewaters; and a cost-effective ground-water protection and renovation program.

GOAL AND OBJECTIVES

The goal of this research program described in the plan is to provide technical data and information for regulatory (both State and Federal) and management decisions on the protection of ground water from pollution. By addressing areas where technical deficiencies exist, this research plan complements a broad base of research which has already been done by EPA and others.

TABLE 1

GROUND WATER RESEARCH PROGRAM CLIENTS
AND RESPONSIBILITIES

STATES AND LOCALITIES	Regional and Site-Specific Ground-Water Management, implementation of delegated Federal programs below.
EPA OFFICE OF WATER	
Office of Drinking Water	Underground Injection Control (UIC) Regulation Implementation
	Public Water Supply Program
	Sole Source Aquifer Program
Office of Water Program Operations	Water Quality Management Program
	Land Application of Wastewater and Sludge and Other Portions of the Construction Grants Program
EPA OFFICE OF SOLID WASTE AND EMERGENCY RESPONSE	
Office of Solid Waste	Hazardous Waste Identification and Disposal Regulations
	Criteria for Classification of Solid Wastes Disposal Facilities and Practices
Office of Emergency and Remedial Response	Superfund
Office of Waste Programs Enforcement	"Imminent Hazard" Enforcement Suits
EPA OFFICE OF PESTICIDES AND TOXIC SUBSTANCES	TSCA Section 4--Physical, Chemical, and Persistence Test Standards
	Pesticide Hazard Evaluations
EPA OFFICE OF AIR, NOISE, AND RADIATION	Regulations for Disposal of Certain Radioactive Wastes

The objectives of the research are to:

- Develop methods for the detection and monitoring of ground-water pollution
- Understand the movement, transformations, and fate of contaminants released into the subsurface environment
- Determine how the behavior, movement, and characteristics of pollutants are altered during their passage through the subsurface environment
- Identify the extent and kind of ground-water pollution resulting from specific sources of contamination
- Assess the strategies and cost effectiveness of aquifer rehabilitation
- Enhance the availability and accessibility of technical information related to ground-water pollution

SCOPE OF RESEARCH

This plan focuses specifically on EPA's research activities to understand the subsurface environment itself. It does not include all ongoing or projected ground-water-related research activities conducted by EPA or other agencies. Major ongoing ground water related research programs which are not included are:

- Determination of the health effects of contaminants in drinking water, including water obtained from aquifers (addressed by the EPA Drinking Water Research Plan)
- Development and evaluation of treatment technologies used for reducing the level of contaminants in drinking water, including water obtained from underground sources (addressed by the EPA Drinking Water Research Plan)
- Development and evaluation of technologies for controlling and managing the release of pollutants into the environment, including into the subsurface environment (addressed by the EPA Industrial Wastewater, Municipal Wastewater, and Hazardous Emergency Response Research Plans)
- Development, evaluation, and standardization of techniques for detecting and measuring contaminants in water, including ground water (addressed by the EPA Water Quality Research Plan, and the Hazardous Wastes Monitoring Research Plan)

In addition, the plan does not discuss the ground-water research activities of the U.S. Geological Survey (USGS). These activities provide information concerning the quantity and overall quality of the Nation's water resources, including ground water; develop fundamental principles and scientifically-based methodology that will be broadly applicable to the study and amelioration of site-specific instances of ground-water contamination; and develop methods and improved investigative tools that can be used to analyze specific contamination problems. Coordination of the EPA program with that of the USGS will continue through the mechanism of the Memorandum of Understanding signed by both agencies on August 5, 1981.

ORGANIZATION

The research plan that follows provides brief background information, a summary of the state of research, and planned activities in each of six research categories which correspond to the six objectives just described. These six research categories first took focus in the fall of 1976, based on the findings of an informal advisory group representing various EPA Offices, universities, the U.S. Geological Survey, state agencies, consultants, and the National Water Well Association. These have subsequently been refined based on comments by the Agency's Science Advisory Board, the National Drinking Water Advisory Council, the Subcommittee on Natural Resources, Agriculture Research and the Environment and its predecessor subcommittee of the House Committee on Science and Technology, and various continuing committees within EPA.

The research categories are:

Methods Development
Contaminant Transport and Fate
Subsurface Characterization

Specific Sources of Contamination
Aquifer Rehabilitation
Information Transfer

The plan presents information on the time frames of specific research activities planned to be conducted and to be completed for the most part within the five-year period FY 1981-FY 1985. The Resources section contains a summary of the funding allocations and permanent full time employees to be assigned to the implementation of the plan for Fiscal Years 1981-1982, organized by location of activity and media. An increase in activity is planned for FY 1982. It is recognized that the levels available in outyears may increase or decrease based on overall Agency priorities and budgetary climate, in which case accomplishments of some of the objectives can be accelerated or extended accordingly. In any case, this plan will be revised and adjusted as needed based on new scientific information, management decisions, and advice from clients and experts.

THE PLAN

METHODS DEVELOPMENT

Background

Improved and less costly methods must be developed to access the subsurface and detect ground-water contamination. For example, there is a need for non-contaminating drilling techniques; pumps which allow accurate sampling of trace organic substances in ground water; methods for detecting biological activity (which may indicate pollution); and methods for locating abandoned injection wells and other possible sources of contamination.

A major difficulty in ground-water methods development is the inaccessibility of the subsurface, which prevents the identification of appropriate sampling locations, and consequently causes unpredictability and high costs in obtaining representative data. It limits the options available for determining ground-water quality, for predicting pollutant movement through the subsurface environment, and for reclaiming contaminated ground water.

State of Research

Some research has been done on a number of geophysical techniques to indicate changes in ground-water quality, but these techniques are not yet adequate for replacing expensive monitoring wells, except under ideal conditions. And even though a great deal of work has been accomplished in methods for installing wells without disturbing the sample, serious problems remain due to alterations of the physical, chemical, and biological properties of the subsurface.

Coring techniques have been developed for collecting samples of anaerobic bacteria in the subsurface. These are currently restricted to rather shallow depths and limited to a few types of geological material.

Methods are available to sample water wells for most inorganic chemicals. Technology is available for collecting uncontaminated, representative samples for trace organic and biological substances in relatively shallow subsurface environments. However, these are not available for deeper ground water.

Although there have been some efforts to find indicators which can represent classes of contaminants, improvements in this area would greatly benefit many aspects of ground-water investigations.

Active research in ground-water investigation methods in the United States includes evaluating tracer techniques, improving well completion and monitoring methods, developing methods to predict the effect on ground water of certain mining activities, and improving technology for sampling in the unsaturated zone.

Major deficiencies in our capability to perform ground-water investigations are:

- Lack of commercially-available submersible pumps for sampling and monitoring trace organic substances
- Inability to measure parameters in the subsurface, such as Eh and ionic strength, which could be important for transport and fate prediction
- Inadequate techniques for detecting leaks in wells
- Lack of availability of non-contaminating tracers
- Lack of non-contaminating drilling techniques except for shallow depths

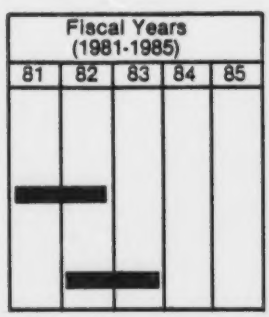
- o Lack of data for judging the type of well casing to use for specific sampling objectives
- o Lack of data for determining the appropriate method for locating abandoned wells
- o Lack of basic data on the effectiveness and applicability of indirect methods of pollution detection, such as surface geophysical techniques

In the international arena, as in the United States, research appears to be shifting to the development of methods for sampling, monitoring, and analyzing trace organic substances. France is developing seismic techniques applicable to shallow geology and the United Kingdom and Israel are working on improving methods to isolate viruses in ground-water samples.

Research Agenda

Current and planned research is designed to address deficiencies by initially evaluating currently available techniques for their effectiveness and applicability in identifying ground-water pollution in various situations; then by adapting and evaluating methods used for other purposes such as petroleum exploration. Lastly, an attempt will be made to develop new, efficient and low-cost techniques.

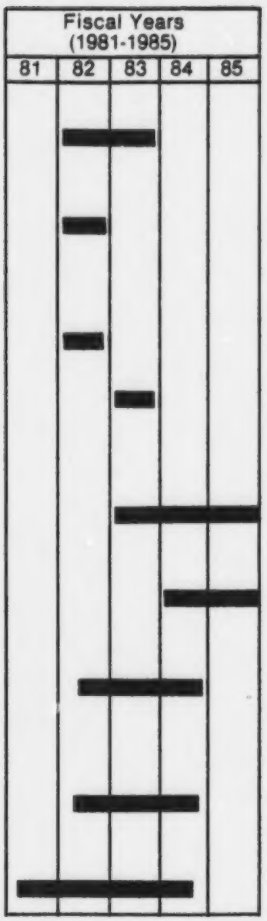
The following is a list of planned activities in the research category of methods development. The bar chart on the right indicates the time frame of each research activity. Lines not ending indicate that the research activity will be completed after Fiscal Year 1985.



METHODS DEVELOPMENT:

- • Development of methods for using advanced surface geographical techniques to locate underground areas of contamination
- • Development of methods for determining the mechanical integrity of injection wells

- Development of methods for locating abandoned wells
- Evaluation of the integrity of existing well casings
- Development of a marketable, non-contaminating submersible pump for sampling trace organic substances
- Evaluation of chemical and isotope tracers
- Development of methods for measuring parameters important to transport, transformation, and fate studies
- Refinement of non-contaminating drilling techniques
- Selection and evaluation of indicator parameters
- Refinement of advanced detection techniques (glass fiber/laser optics) to reduce monitoring costs
- Development of unsaturated zone monitoring systems for early detection of pollution



CONTAMINANT TRANSPORT AND FATE

Background

Information on contaminant transport and fate is needed in order to evaluate and predict the effects of man's activities on ground-water quality. The characterization of movement of various contaminants through different geological materials, including an understanding of sorption, chemical and biological degradation, volatilization, and fixation, is required.

Our studies in this category develop quantitative information concerning contaminant movement and transformation in saturated and unsaturated subsurface zones. In increasing order of complexity, the classes of contaminants for which this information is required are: salts; nutrients (primarily nitrogen and phosphorus); metals; organic substances; and bacteria, fungi, and viruses.

State of Research

Most transport and fate studies in the past have addressed inorganic contaminants such as compounds of iron, nitrogen, phosphorus, and sulfur, and, to a lesser extent, metals. Knowledge of transport and fate is more limited regarding the movement of metals and nitrogen compounds than of other inorganic compounds.

Knowledge on the transport and fate of organic contaminants in the saturated and unsaturated zones is particularly fragmentary. Until very recently, a false sense of security concerning this problem existed among most regulatory and research groups because it was inaccurately believed that the attenuating capacity of the soil mantle for organic compounds was great. New information, however, while it permits only generalized conclusions concerning

the movement of a few organic compounds in the subsurface environment, does establish that many such compounds have been found in the ground-water environment, that they undergo transformations, and that their movement is difficult to monitor. Mathematical formulas capable of providing a first-generation predictive ability for a selected group of organic materials in some subsurface environments are under development.

Considerable attention has been devoted to the transport and fate of pathogenic microorganisms in the subsurface environment because of the long-recognized health implications associated with this class of contaminants. Nevertheless, knowledge in this area is very limited, particularly in the case of viruses.

Ground-water transport and fate research by State agencies and universities in the United States is mainly concerned with inorganic compounds such as nitrates and metals. Research on organic substances is conducted largely by the U.S. Geological Survey and by EPA, who also address inorganic chemicals.

Deficiencies still exist, however. A great deal of research is required in contaminant transport and fate, especially on organic and biological contaminants. Further, research on metals, particularly on changing oxidation-reduction states and speciation, and on nitrogen, to characterize the transport and transformation of the compounds of this element in the subsurface environment, is required. Extensive research will be required to identify classes of contaminants which have similar transport and fate characteristics and to select an indicator for each of these classes, as discussed under methods development. This is particularly true with respect to organic contaminants, bacteria and viruses, and to a lesser extent metals.

Current EPA research efforts on organic chemicals focus on the use of simple soil columns to determine the relative mobility of selected low-molecular-weight organic compounds which have health significance and which have been identified in ground-water contamination incidents. Research on processes other than simple mobility is just beginning, and will concentrate on biodegradation and sorption. By 1983-1985, classes of compounds with similar transport and fate characteristics will be defined and evaluated. It is likely that the relative influence of the processes will be different for each class.

Physical models in the laboratory have been constructed for study of the processes described above. These models may also provide a quick screening method for judging the environmental mobility and persistence of specific chemicals of interest (particularly useful for hazardous waste identification, pesticide registration, and toxic substance environmental review).

First-generation mathematical models have recently been made available which can utilize the standard information required for pesticide registration to predict the environmental mobility of selected pesticides. Where field evaluation has been possible, results have been encouraging. A two-dimensional model which will ultimately be capable of using the process information from laboratory and field studies on classes of organic chemicals is under development. By mid-1983, limited field evaluations of the two-dimensional model will be completed.

Studies are also under way to determine the subsurface transport and fate characteristics of viruses. Little success has been achieved to date in determining which viruses will move and survive in which environments. Work

now directed toward gaining understanding of the processes involved in transport and inactivation will likely continue for 3 to 5 years.

Most transport studies outside the United States are concerned with metals and conservative pollutants. Sweden, the Netherlands, Switzerland, Germany, and to some extent the United Kingdom and others, are also studying the subsurface transport of organic substances.

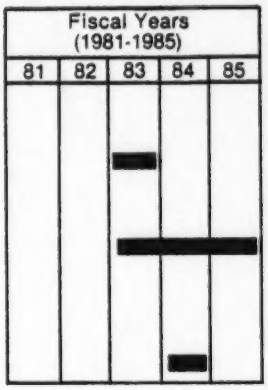
Research Agenda

To sum up, EPA plans the following activities in the research category of contaminant transport and fate in response to these needs. The bar chart on the right indicates the time frame of each research activity.

CONTAMINANT TRANSPORT AND FATE:

- Determination of the mobility of selected low-molecular-weight organic compounds
- Development of a one-dimensional mathematical model for mobility prediction
- Construction of a laboratory physical model
- Development of protocols for physical model construction
- Development of a two-dimensional mathematical model for mobility prediction
- Development of screening protocols for determining chemical mobility
- Development of mathematical models for virus transport and survival
- Determination of biodegradation and sorption characteristics of low-molecular-weight organic compounds
- Determination of biodegradation and sorption characteristics of other classes of organic chemicals

- Completion of a sensitivity analysis of the two-dimensional model to determine important parameters
- Field evaluation of physical and mathematical models
- Determination of the effects of other chemical and physical processes on the transport and fate of organic substances



SUBSURFACE CHARACTERIZATION

Background

Subsurface characterization describes those studies aimed at understanding the subsurface environment in terms of its effect on pollutant transport, transformation, and fate. These studies characterize the physical, chemical, and biological character of the subsurface environment and determine how these characteristics alter the movement of contaminants through such an environment. This information will be the foundation upon which we can develop predictive models to evaluate ground-water pollution potential and improve our ability to identify and predict changes which will occur as a result of contaminants in the subsurface environment.

State of Research

Through the efforts of researchers in such fields as agriculture, petroleum engineering, geology, geochemistry, and hydrology, we know a great deal about various aspects of the composition and structure of the earth's crust and how water moves through it. Unfortunately, available information is inadequate to describe what occurs when pollutants are introduced into subsurface regions.

Such information is needed for predicting the impacts of ground-water contamination, and for developing criteria for waste disposal site selection. Initial research efforts to fulfill this need are directed toward defining the nature of the subsurface environment in terms of its innate physical, chemical, and biological characteristics and developing a unified theory correlating these findings with contaminant transport. Before this correlation can be attempted, considerable research will be required under the

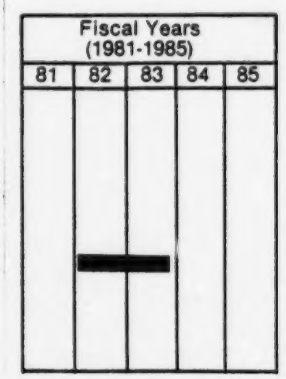
methods development category, for example, to develop a method for directly or indirectly measuring redox potential at greater depths.

Although little subsurface characterization research on deep aquifers is under way outside of the United States, Australia, Germany, Poland, and the Netherlands do actively collect pertinent data on upper soils as part of land application projects. There is some evidence that work on deeper aquifers is under way in the USSR, but specifics are difficult to obtain.

Research Agenda

EPA's research program for subsurface characterization has been developed in cooperation with experts from universities, government, and industry. It will examine geochemical, hydrological, mineralogical, and biological parameters to determine their roles and relative importance in predicting ground-water pollutant transport and fate. The research plan takes into account and advances ground-water information already accumulated by petroleum geologists and water well drillers.

The following is a list of planned specific activities in the research category of subsurface characterization. The bar chart on the right indicates the time frame for each research activity. These research activities will rely heavily on information produced by the U.S. Geological Survey.

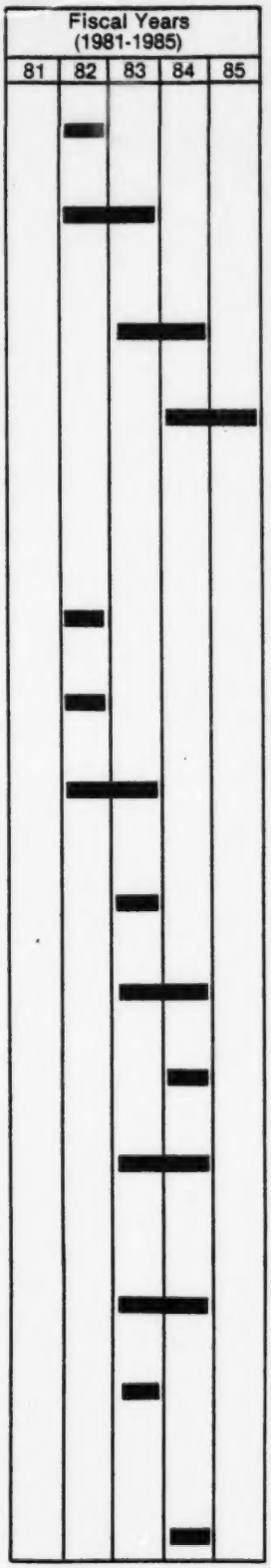


SUBSURFACE CHARACTERIZATION:

1. Generic definition of subsurface system

   - Definition of regional and seasonal hydrogeological variations with respect to the movement and transformations of pollutants

   - Determination of subsurface distribution of potential adsorbents, clays, subsurface



organic matter, and sesquioxides

- Determination and distribution of indigenous and allochthonous microorganisms
- Development of methods for determining as many geological and hydrological parameters as possible without drilling
- Development of a set of benchmark soils for use in laboratory testing

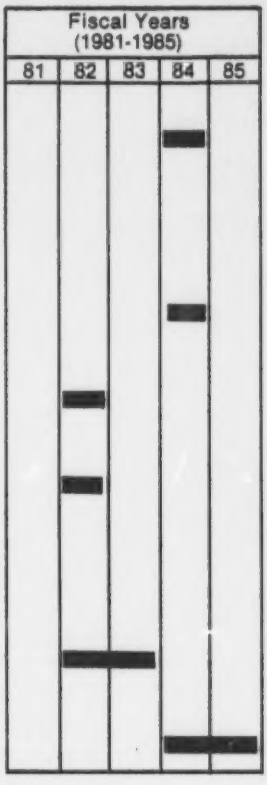
2. Laboratory and field studies

Laboratory studies

- Evaluation of specific soils and specific organic compounds
- Determination of benchmark organic chemicals
- Determination of adsorption processes operating for each major organic chemical group
- Determination of the extent of biotic degradation of synthetic organic chemicals, resulting products, and optimum degradation conditions
- Determination of the rate coefficients from a study of degradation kinetics
- Determination of the extent of abiotic degradation
- Determination of the effects of nutrients and organic compounds on microbial activity

Field Studies

- Examination of existing hazardous waste sites through field observations and laboratory testing
- Evaluation of data already collected from existing sites and neighboring environs
- Verification in the field of trends deduced from field investigations or laboratory experiments using undisturbed sites of similar geology and hydrogeology



- Acquisition of pertinent engineering experience and development of best judgment techniques

Interpretation and mathematical analysis

- Correlation of degradation with geochemical and mineralogical parameters, separating biotic and non-biotic degradation
- Development of mathematical models for organic degradation and movement
- Implementation of feedback from model designers to experimenters and vice versa

3. Application

- Development of a predictive model for evaluating the effects of specific chemicals at a specific site
- Determination of whether environmental modification can increase contaminant degradation

SPECIFIC SOURCES OF CONTAMINATION

Background

In order to accurately define the nature and extent of ground-water contamination and to develop programs for protection of ground-water quality, specific sources must be studied. It is important to note that the previously described research categories are necessary precursors to investigations of specific sources.

Table 2 lists the potential sources of ground-water contamination.

The technical information required for managing specific sources of contamination consists of: (1) the number and location of the sources; (2) the characterization of contaminants entering and leaving the source; (3) the availability, feasibility, and effectiveness of control or management measures, including design and construction, operation and maintenance, closure, and on-site treatment of effluents; and (4) methods for monitoring the effectiveness of controls.

State of Research

So much information about specific sources of contamination has been gathered that an exhaustive discussion of the subject could not be attempted in this document; however, some examples can illustrate the deficiencies in information. Research on septic tanks to date has mostly been concerned with design and the contribution to ground water of such contaminants as coliform bacteria, nitrogen, phosphorus, and total dissolved solids. However, little information exists on viruses, trace organic compounds, or nitrogen losses to the atmosphere.

TABLE 2

POTENTIAL SOURCES OF CONTAMINATION

Waste Disposal Sources

- Landfills, Dumps, and Surface Impoundments
- Mining Waste Disposal Sites
- On-lot Waste Water Disposal Systems
- Radioactive Waste Disposal Sites
- Sludge Management Systems via Land Spreading
- Underground Injection Wells
- Land Treatment Systems for Municipal Waste Water
- Seepage Pits

Other Sources

- Abandoned Wells
- Accidental Spills
- Agricultural Practices
- Artificial Recharge
- Highway De-icing Practices
- Petroleum Exploration and Development
- Underground Storage Tanks and Pipelines
- *In Situ* Development of Coal, Oil Shale, and Tar Sands

Although leachates from municipal landfills and dumps have generally been characterized, the presence of industrial wastes in municipal dumps makes such a characterization very difficult. In most cases, information on the location and nature of these wastes does not exist.

There have been a number of investigations relating to the leakage of surface impoundments of industrial chemical waters. The EPA Surface Impoundment Assessment Study, some results of which have been recently published, indicates a potential negative impact of this method of waste disposal on ground water.

Most research associated with the development and production of oil and gas deals with brine disposal, whereas little information is available concerning the impacts of drilling fluids, chemicals used in treating wells, corrosion inhibitors, and interconnection and contamination of overlying aquifers. In addition, little is known about possible ground-water contamination associated with the various technologies of enhanced oil and gas recovery, which utilize large volumes of surfactants, polymers, and other chemicals. Planned research in pollution associated with petroleum exploration and development will initially focus on enhanced recovery.

Synthetic fuel technology and other emerging energy technologies may pose serious environmental problems with respect to ground water. The underground gasification of coal, for instance, can release contaminated water, which may migrate into uncontaminated aquifers. Subsidence from *in situ* coal gasification or oil shale retorting may lead to the interconnection of overlying aquifers. The migration of contaminated water, although slow from *in situ* cavities, may pose threats to the quality of adjacent aquifers. The

development of geothermal resources, geopressurized brines, and tar sands as energy sources also poses potential ground-water pollution problems. Information is needed about these new potential sources of contamination.

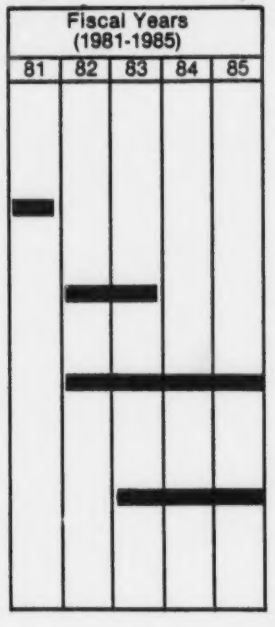
Specific sources of contamination are being studied throughout the world. These studies predominantly deal with waste dumps, agriculture, ground-water recharge, land application of wastes, and well construction. For example, Belgium has worked with industrial spills of hydrocarbons and New Zealand is concerned with agriculture, septic tanks, and land application projects. The USSR has collected considerable data associated with mining.

Research Agenda

The following is a list of planned activities on specific sources of contamination. The bar chart on the right indicates the time frame for each research activity. Lines not ending indicate that the research activity will be completed after Fiscal Year 1985.

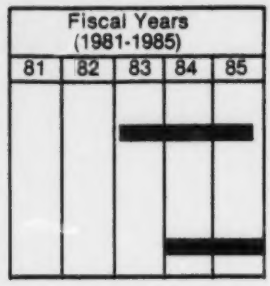
SPECIFIC SOURCES OF CONTAMINATION:

- Development of a manual for determining septic tank densities in a given geographic area. This management method will prevent ground-water pollution from organic contaminants and viral pathogens
- Determination of the nature and extent of ground-water pollution from urban runoff
- Characterization of ground-water pollution from emerging energy technologies
- Evaluation of the effectiveness of various remedial actions at uncontrolled waste disposal sites
- Evaluation of the nature and extent of ground-water pollution from unlined or leaky surface



impoundments

- Characterization of potential ground-water pollution from petroleum exploration and development operations.



AQUIFER REHABILITATION

Background

Aquifer rehabilitation refers to the restoration of water quality in an aquifer after it has become contaminated. This is often difficult with present technology and can be an expensive undertaking with respect to both money and time. The difficulty and expense emphasize the need to concentrate on aquifer protection rather than restoration. Unfortunately, there are many cases where the subsurface environment has been contaminated, and restoration for industrial, agricultural, and domestic use may be imperative. Therefore, there is a need for research on aquifer rehabilitation techniques in order for decision-makers to choose the most cost effective option.

The process of rehabilitating an aquifer requires two kinds of technology. One is actual rehabilitation of the contaminated saturated and unsaturated zones and the other is the removal, or isolation, of the source of contamination. Basic to these needs is information for determining the source of aquifer contamination and a decision process to determine whether remedial action is necessary or feasible and the extent of rehabilitation which is required. Since some contaminants pose more of a potential threat to public health and safety than others, economic, social, and engineering information is required to decide whether rehabilitation or development of alternative water supplies is preferable.

State of Research

Aquifer rehabilitation studies conducted to date have been directed toward prevention, procedures for control, and methods for monitoring. The EPA Hazardous Waste Enforcement Task Force has initiated some rehabilitation

studies. Rehabilitation has been demonstrated on a small scale in Virginia. In addition, case histories of 116 ground-water contamination incidents reveal that remedial action is usually complex, time-consuming, and expensive.

The only large-scale research in aquifer rehabilitation is ongoing in Switzerland and Germany. The Swiss have established emergency procedures for pumping and treating contaminated ground water in spill areas. A university in Germany has established a research and demonstration project for pumping, treating, and recharging contaminated ground water.

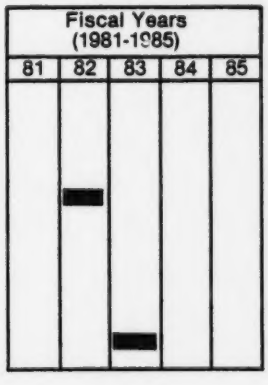
Research Agenda

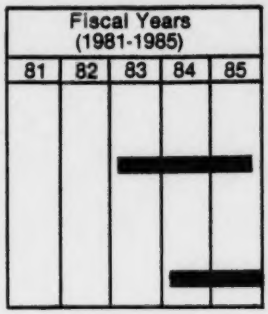
EPA research in the area of aquifer rehabilitation will seek new solutions as well as extensions or improvements of existing technology. Extensive research is required on the physical or hydraulic isolation of waste sources and the treatment of contaminated ground water either in situ or upon removal.

The following is a list of planned activities in the research category of aquifer rehabilitation. The bar chart on the right indicates the time frame for each research activity. Lines not ending indicate that the research activity will be completed after Fiscal Year 1985.

AQUIFER REHABILITATION:

- Completion of a literature search on rehabilitation methods that have been attempted and a paper evaluation of the relative effectiveness of various methods
- Determination of the estimated costs of aquifer reclamation techniques versus costs of alternate drinking water supply development or point-of-use treatment





- Determination and evaluation of the effectiveness of remedial actions at hazardous waste sites to clean up ground water

- Determination of the potential for manipulation of subsurface characteristics to enhance aquifer restoration

INFORMATION TRANSFER

Background

Information transfer describes the conversion of technical information obtained through research to some media available to the user of that information. The ability of decision-makers to react to instances of ground-water pollution, as well as the ability of managers and regulators to protect ground-water quality is hampered by information deficiencies, a lack of training, and poor information exchange.

Reports are especially needed to describe the proper methods for conducting field investigations, including monitoring well construction and siting, proper sample collection, and the prediction of contaminant transport and fate. This information can take several forms including state-of-knowledge documents, how-to manuals, and journal articles.

The most common and useful ground-water information is in the form of technical reports and publications in technical journals. Ground-water science is a multidisciplinary effort. Articles on ground-water quality may be found in journals of geology, hydrology, engineering, chemistry, agriculture, ecology, and microbiology. The U.S. Geological Survey has for many years published ground-water reports, primarily related to water quality and availability. Data on water quality were usually, though not always, limited to the more easily measured constituents such as chlorides or sulfates or other natural pollutants. Since 1967, EPA and its predecessor agencies have published reports on ground-water research, mainly oriented toward organic and microbial pollution. Also, many of the State water agencies publish reports on the status of their ground-water resources.

There are three U.S. technical journals devoted exclusively to ground water -- Water Well Journal, primarily concerned with water well drilling; Ground Water, devoted to technical and scientific aspects of ground-water quality and management; and Ground Water Monitoring Review, a new quarterly which surveys the state-of-the-art. The Water Information Center of Syosset, New York, publishes a monthly Ground Water Newsletter, which is a synopsis of current events related to ground-water management. The Ground Water Heat Pump Journal restricts its articles primarily to engineering problems associated with heat pumps.

Another forum for the transfer of ground-water information is technical meetings. A number of national technical meetings, most notably those sponsored by the American Geophysical Union, have devoted a portion of their programs to ground-water-related issues. Since 1971, EPA and the National Water Well Association have conducted four national Ground-Water Quality Symposia and published their proceedings.

Because of recent interest in ground water and ground-water management, in 1978 EPA established a Clearinghouse for Ground-Water Models at the Holcomb Research Institute. The purpose of the clearinghouse is to make existing ground-water models more accessible to the user and improve communication between management and those who provide technical services employing models.

Agenda

The results of the research described above will be disseminated through manuals, reports, journal articles, workshops, seminars, and symposia. The medium chosen depends on the intended audience and the nature of the research results. An information center has been made available to all parts of the

Agency, other Federal Agencies, consultants, and particularly the States. This center now provides a ground-water literature search capability to managers, decision-makers, and regulators. The available literature will be expanded over the next two years.

RESOURCES

Table 3 is an operational breakdown of the budget for ground-water research as presented in this plan. The data reflect current allocations for FY 81 and FY 82. These are broken down by EPA program areas and laboratories or headquarters offices responsible for implementing and providing research oversight.

TABLE 3

EPA GROUND WATER RESEARCH RESOURCES
(FISCAL YEARS 1981 - 1982)

	Fiscal Year 81		Fiscal Year 82	
BY MEDIA	Funding*	PFTE*	Funding*	PFTE*
Drinking Water				
HQ	47.4	1.0	51.4	1.0
Ada	2224.2	18.5	4907.7	25.3
Las Vegas	0	0	519.0	1.0
Subtotal	2271.6	19.5	5478.1	27.3
Hazardous Waste				
Ada	579.1	3.3	1418.8	6.0
Las Vegas	300.1	0.9	270.0	1.3
Subtotal	879.1	4.2	1688.8	7.3
Energy				
Ada	47.9	0.5	317.0	0.3
Las Vegas	250.0	1.0	210.4	0
Interagency	370.0	0	0	0
Subtotal	667.9	1.5	527.4	0.3
Superfund (Ada)	0	0	300.4	2.0
Grand Total	3818.6	25.2	7994.7	36.9
BY LOCATION				
HQ	47.4	1.0	51.4	1.0
Ada	2851.2	22.3	6943.9	33.6
Las Vegas	550.0	1.9	999.4	2.3
Interagency	370.0	0	0	0

*Funding (thousands of dollars); PFTE (permanent full time equivalencies).

NOTE: The FY '81 funding above does not include $871.4K, which was part of the Agency's FY '81 rescission request. Congress has not allowed the request, and funds will become available. However, they will be committed when the Agency has reexamined its priorities in light of work in progress, FY '82 plans, and Congressional directives.

HQ - EPA Headquarters, Office of Research and Development.

Ada - R.S. Kerr Environmental Research Laboratory at Ada, Oklahoma.

Las Vegas - Environmental Monitoring Systems Laboratory at Las Vegas, Nevada.